Original Article

Fruiting Species Influence the Seasonal Use of the Habitat by Sloth Bear in and around Balaram Ambaji Wildlife Sanctuary, Gujarat, India

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Abstract

Sloth bear populations in India are threatened, and the ecology and distribution of the species occurring in the region's protected areas are known, but there is no scientific basis underlying management strategies for sloth bear. We used bear indirect and opportunistic direct signs like feeding site, scats, foot print trails, claw marks on climbing trees, to study habitat use and distribution of sloth bear (*Melurus ursinus*) across Balaram Ambaji Wildlife Sanctuary and Danta Reserve Forest, Gujarat, India from April, 2010 to January 2011. We survey 40 grids (5 × 5 km) 3 km signs survey = 120 km × 3 = 360 km and total 766 bear signs were recorded, and for vegetation we surveyed 40 grids × 2 km vegetation transect = 80 km were sampled. A total of nine (9) vegetation types were recorded and the bear sign where crossed check with the vegetation forest type. Fruits appear to be a key resource for sloth bears, and factors affecting fruit abundance or seasonality will affect bear foraging as well as the humans to depend on such fruits as a food common resource. Knowledge of this relationship will allow managers to be more proactive in managing bears. We recommend using sign surveys for monitoring changes in sloth bear presence, as they are inexpensive, efficient, and can be conducted by trained rangers.

Introduction

The sloth bear is an access wide variety of habitats, including wet or dry tropical forests, savannas, scrubland and grasslands (Joshi *et al.*, 1995; Garshelis *et al.*, 1999a; Akhatar *et al.*, 2004; Ratnayeke *et al.*, 2007; Mewada, 2015). In Gujarat out of five protected areas where sloth bear occurs, i.e. Shoolpaneshwar, Jambughoda, Ratanmahel, Jassore and Balaram-Ambaji Wildlife Sanctuaries (Mewada and Dharaiya, 2010; Mewada 2015). According to Garshelis *et al.* (1999b) Balaram Ambaji and Jassore Wildlife Sanctuaries were having highest sloth bear densities than anywhere in India. North Gujarat forests, which is very sparse, patchy and dryer forested areas have created sloth bear image frightening among the locals of Balaram-Ambaji Wildlife Sanctuary (BAWLS), Danta Reserved Forest (DRF) of Banaskantha district. In BAWLS and DRF, habitats available to sloth bears are highly disturbed, small-clustered forested patches with small human settlements in between and agriculture fields (Mewada and Dharaiya, 2010). Moreover, people increasingly collect non-timber forest produce (NTFP), which leads to confrontation with

bears. It has great concern for the conservation and management issues with local people and sloth bear, whose status is vulnerable and precarious. The human-bear conflicts are on a hike, which needs checking and attention to resolve, for conservation of threatened species and management in defragmented and small forest patches (Murthy and Shankar 1995; Chauhan *et al.*, 1999; Dharaiya and Ratnayeke, 2009; Mewada and Dharaiya, 2010).

As off now scattered information is available on the habitat use, food, habitat, activity and movement patterns and behaviour of sloth bears in these forested areas of BAWLS and DRF, and nothing is known to man-altered situations in North Gujarat forests. Habitats available for sloth bears within the ranges are namely, Danta East, Danta West, Ambaji North, Ambaji South, Amirghad and Palanpur ranges and along highly degraded surrounding forests. Optimum habitats that can support the population of sloth bears in these areas are very less but inside and fringed of these forested areas, some of the boulders with small hillocks are available, these habitats offer suitable 'den' sites for sloth bears which are quite close to human settlements. Due to which sloth bears are forced to use these degraded forested areas, both bears and humans dwell

smoothly in these forested areas for the common resource dependency. With this study authors just tried to analyse the bear diet and the distribution of fruiting trees. By knowing, the seasonal food preference and the forest patches, which are having a high density of the fruiting trees, can be utilized for the management purpose to reduce the conflict and helps in effective conservation of the sloth bear.

Materials and Methods

Study area

The Banaskantha district lies between 23° 35' to 24° 43' North latitudes and 71° 0' to 73° 0' East longitudes on the Banas River. The district is in the Northwestern a part of the Gujarat and shares its boundary with Rajasthan state. The total area of Banaskantha district is 10754.7 km², which constitutes 5.5% percent of the total area of the State. From the viewpoint of area, the district is the third largest in the state. Banaskantha district is spread over flat desert like saline area in the west and undulating and hilly terrain in the north and the northwest area. The total forest area covered under the Banaskantha district reported is 1605.64 km² out of which 970.84 km² is Reserved Forest; 18.74 km² is protected forests and 616.06 km² is unclassified forest.

The abiotic environment of the North Gujarat Region (NGR) experiences a high variation in temperature with minimum going down to 5 °C in winter and maximum to 46 °C in summer. Usually the monsoon season experiences an average rainfall of 765 mm, which provides ideal environmental condition for the occurrence and abundance of diverse flora and fauna. The topography varies from plains with an elevation gradients of 10 m to 600 m above MSL. The forest tracts of the area are highly undulating with broken ranged of hill in height ranging from 170 to 600 (MSL) meter above sea level. Most of the hilly tract is highly sloppy with almost 90 to 100 percent slopes in places. The important hills of the study area are Koteshwar, Gabbar, Surmata hills, Diwania hills, Kaleto hills, Trishulia hills, Virampur hills, Hathidra hills and Chamunda hills. These hills and hillocks are forming a network leading to the bigger mullahs, entering the plains and draining into the river Banas (Singh *et al.*, 2002).

The biotic units of the area by its flora in the forest is classified by Champion and Seth (1968), this region supports Southern dry mixed deciduous forests 4B3, 4B4 - (5A/C3) which is further classified into its subgroups 5/E1, 5/E1/DS1, 5/E2, 5/E5, 5/E7 and 5/E9. The forest on hills supports a very good population of *Boswellia* and *Lannea* forests at the top, at the middle of the hills covered by the *Acacia* and at the foothills are dominated by *Anogeissus* forests. Apart from these species, the Ambaji range supports good density of the teak (*Tectona grandis*), and bamboo species. The unique ecosystem harbours 483 species of plants including 107 of trees, 58 of shrubs, 219 of herbs, 49 of climbers, 40 of grass and 10 species of lower plants (Pandey, 2004). Among the fauna, the area supports good diversity of the ground dwelling birds and the other migratory wetland birds in migratory season. Mammalian fauna is recorded very less in the region. Bluebull (*Boselaphus tragocamalus*) is one of the most common large mammals in entire area, while other ungulate population is found too low in the region. There are more records of small to medium sized carnivores/omnivores like small Indian civet (*Viverricula indica*), jungle cat (*Felis chaus*), Indian ratel (*Mellivora capensis*), sloth bear (*Melursus ursinus*) and leopard (*Panthera pardus*). According to the study carried out by Dharaiya (2008-2009) recorded 28 species of mammals for the entire North Gujarat region.

Methodology

The first few days were devoted for general reconnaissance of the areas to get an idea of the forest cover types. Different habitat used by sloth bear were categorised and random sampling were done to quantify the vegetation. Primary analysis has been carried out to obtain the values of various parameters for calculating grid base sampling. A grid of 5 x 5 km lay on BAWLS map and in each grid vegetation transect were laid of 1 km length. Each grid was identified having forested area and selected for sign survey trails (SST). Sloth Bear sign information was collected from grid survey, 3 km in each selected grid were walked, bear sign was recorded, and an encounter rate was calculated. Detect ability of mammal sign may vary among different habitats and among types of sign. To minimize biases due to varying detectability rates, we used a fixed-width SST and only considered Sloth Bear sign within 5 m on either side of the SST (10 m transect width) (Fig. 1A).

For the bear survey: The study areas were regularly surveyed by inspecting bear signs in 5 x 5 km grid overlaid on 1: 50,000 scale map to determine presence or absence of sloth bear. The sign survey was also supported by interviews of local villagers for first-hand knowledge of the visiting forests in the area who would be more likely to report on the presence or absence of sloth bears. With assistance from local tribesmen, we verified reports from villages by surveying grid cells for sloth bear sign such as tracks, scats and diggings; to identify areas used by sloth bears. All locations of the tracks, scats or another were mapped using a Garmin GPS.

A supervisory classification was done using field-collected data on habitat characteristics. The habitat types were identified primarily on structure of vegetation communities.

For the vegetation survey: The first few days were devoted for general reconnaissance of the areas to get an idea of the forest cover types. Different habitat used by sloth bear were categorised and random sampling are done to quantify the vegetation. Sampling of trees was done within 10 m radius circular plots which are repeated every 100 m point along the trail of 1 km. Within 10 m, radius plot tree and liana counted and inside 10 m radius plots, 5 m radius plots lay to count shrubs and climbers and two one (1) m² plots on the N-S corner were laid for ground vegetation. Woody species exceeding 30 cm at GBH were considered as a tree, whereas less than 30 cm at GBH were considered as a shrub (Fig. 1B).
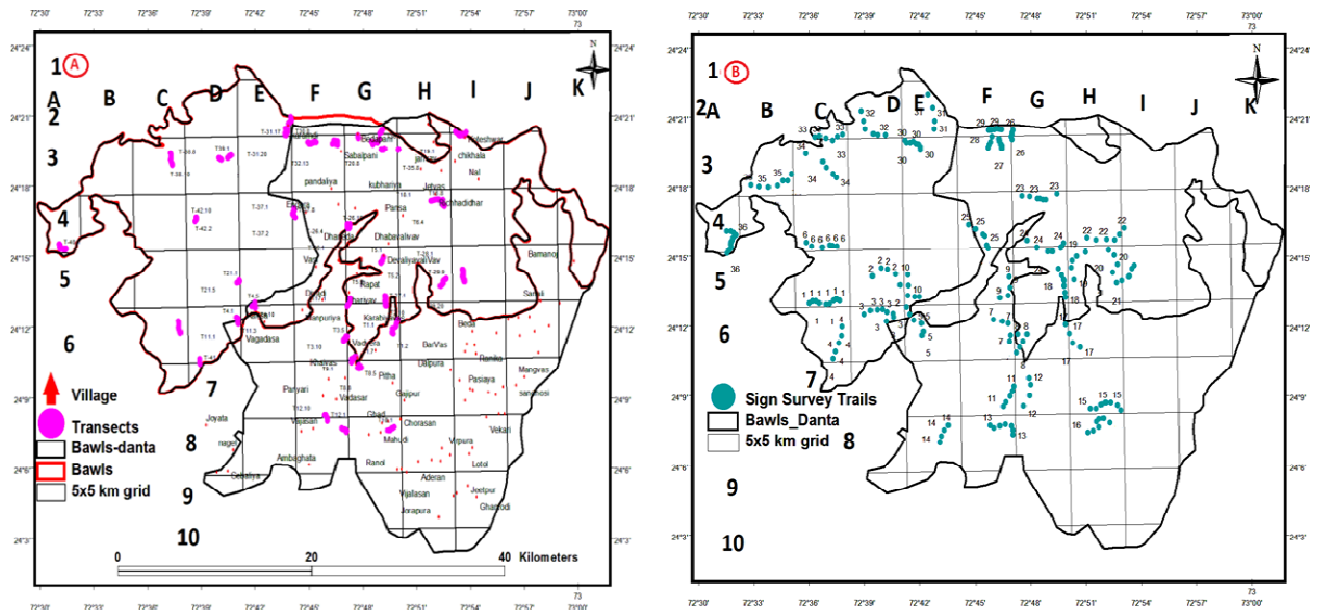
Fig. 1. A-Vegetation transects location in grid of study area; B- Sign survey trails in grid of study area

Results

Seasonal availability of the sloth bear food plant in different forest types of the study areas may help in knowing the seasonal forest use by the sloth bear. This study was carried out to identify available patches of high fruiting plants and frequently utilized by the sloth bear during its fruiting seasons.

Total 225 km sign survey was done in the study area (25 grids of 5×5 km, 3 km SST were walk for three different seasons; 25 grids × 3 km = 75 km × 3= 225 km) and total 766 bear signs were recorded in which scats (67%), foot print (14%), scratches on the land and on the tree trunks, etc. (8%), trail (series of footprints in a walk) (5%) as the area are much rockier or the gravel base so the continuous footprint or the trail reports was difficult in this area. During the entire period of survey only 3% of digging was observed, it is because the soil is very hard to dig out. Only 2% feeding site were located during the study period, which are mainly fruits, honeycomb and water holes. Only one time direct sighting of SB was observed during sign survey (Fig. 2).

In the study area, nine different vegetation types were observed and apart from these two unique habitat types were also observed i.e., boulders and rocky. The boulder area mainly harbours large stones or boulders, which can be considered as very good den, site for the sloth bear for relaxing and conceal during the inactive period (daytime) in the area. It is clearly seen in the Fig. 3 that the boulder habitat is much-used (2.89 sign/km walk) by the bear than the rocky habitat (0.44 sign/km walk). Maximally used habitat was reported in the Riverine forest (4.11 sign/km walk) which is followed by boulder (2.28 sign/km walk), crop fields (2.56 sign/km walk), PABMF= *Prosopis, Acacia* mixed forest (2.04 sign/km walk), ZMF= *Ziziphus* mixed forest (1.74 sing/km walk), P scrubs= *Prosopis* scrubs (1.41 sign/km walk), MF=Mixed Forest (1.33 sign/km walk), D scrubs= *Diospyros* scrubs (1.22 sign/km walk) and DMC scrubs= *Diospyros- Miliusa* and *Cassia* scrubs (1.06 sign/km walk) (Fig. 3).

Fig. 4. A and B and Table 1 represents the grid wise sign encounter rate and locations of transects along with conflict zone. Very high sign encounter rate (VHER) was recorded in grid F8 and nearby villages of Vajsan and Ambaghat; high sign encounter rate (HER) of sloth bear was recorded in grid number A4, F3 and H5 and nearby villages of Sabal Pani, Piplivav and Dhablivav. While it is clear that, the sloth bear habitat use in the study area is more or less uniformly.
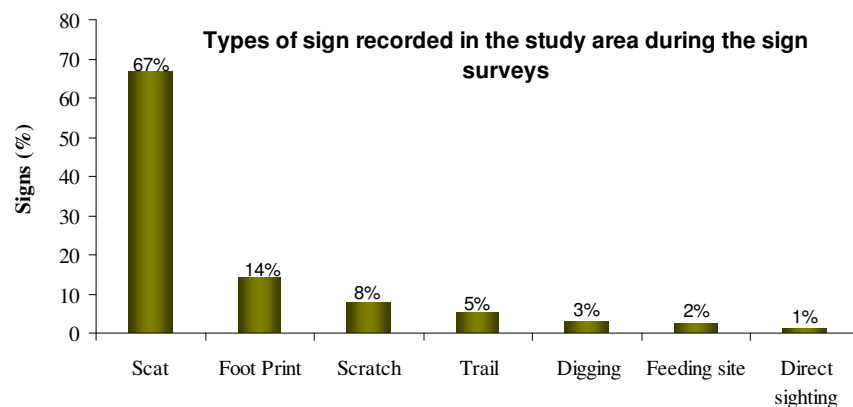

Fig. 2. Types of sloth bear sign recorded in the study area during the sign survey
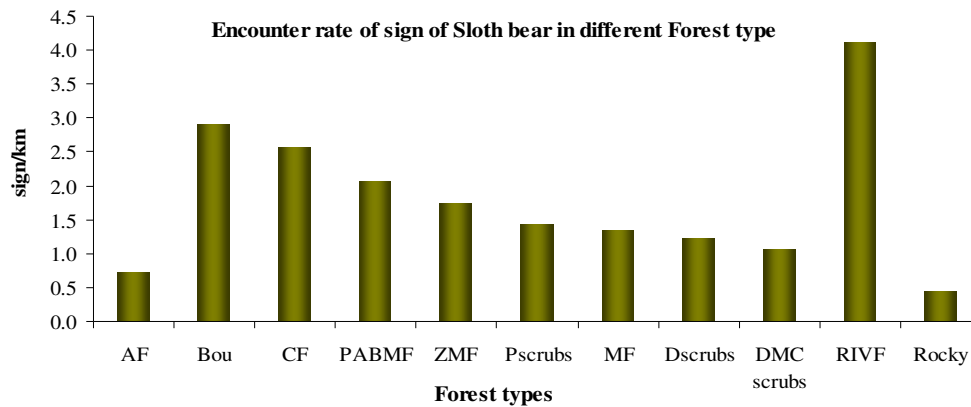
Fig. 3. Encounter rate of the sloth bear sign evidences in different forest types of the study area, AF= *Acacia* Mix Forest, Bou. = Boulders, CF= Crop Filed, DMC scrubs= *Diospyros, Miliusa, Cassia* scrubs, D scrubs= *Diospyros* scrubs, MF=Mix Forest, PABMF= *Prosopis, Acacia, Butea*, Mix Forest, P scrubs= *Prosopis* scrubs, RIVF= Riverine Forest, ZMF=*Ziziphus* Mix Forest
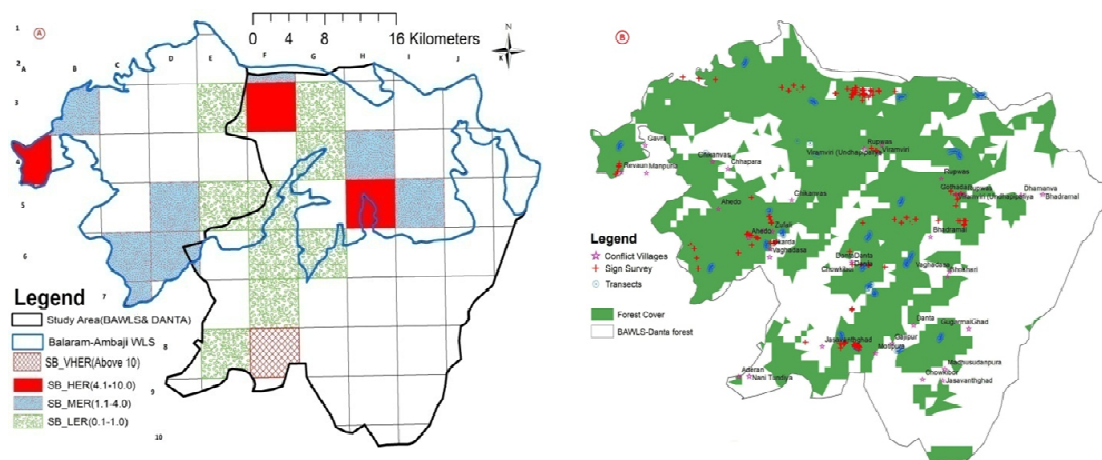

Fig. 4. A- Distribution of the sloth bear sign encounter rate in different grids of the study area; B- Sign survey trails in different forests of the study area

Table 1. Encounter rate of sloth bear sign in the study area shown grid wise (sign/km in the 5 × 5 grid)

Grids	A	B	C	D	E	F	G	H	I	J	K
1	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2	- -	- -	0.67	- -	- -	2.44	- -	- -	- -	- -	- -
3	- -	1.33	- -	- -	0.44	7.11	0.67	- -	- -	- -	- -
4	5.00	- -	- -	- -	- -	- -	0.67	1.33	- -	- -	- -
5	- -	- -	- -	2.44	1.00	0.33	- -	7.33	2.67	- -	- -
6	- -	- -	4.00	3.67	0.67	0.67	0.67	- -	- -	- -	- -
7	- -	- -	1.33	- -	- -	0.33	- -	- -	- -	- -	- -
8	- -	- -	- -	- -	0.33	10.67	5.00	- -	- -	- -	- -

Overall, 190 plots (10 m radius) were laid covering 9 different forest types. In mixed forest types, maximum numbers of trees were observed (Table 2) and maximum density was observed for *Diospyros melanoxylon* followed by *Miliusa tomentosa*. Maximum density of *Ziziphus mauritiana* was observed in *Acacia tortilis* scrub forest. Good population of *Cassia fistula* was found in *Diospyros* and *Butea* mixed forest. The *Cassia fistula* is distributed mainly in the central part of the sanctuary this species locally known as Garmalo (Amaltash), this is also an important medicinal plant. The plant occurs in the grid E-5, E-6 and I-3 in high densities and lowest densities in grid E-2, D-6, F-8

and G-5. This species is present in Sloth Bear scats throughout the year and available 26.32% in monsoon, 7.36% in winter and 34.29% during summer, and supports Sloth Bear food for the whole year. The highest density of *C. fistula* is 35.03 per ha and the lowest density is 3.18 per ha. *Diospyros melanoxylon* is distributed in the central part of the sanctuary this species locally known as timru (Tendu), this is an important NTPF collection plant for India. The plant occurs in the grid G-6, G-7, H-5 and I-4 with the highest density and with low density in grid D-5, D-6, F-7, F-8 and I-3. This species is present in sloth bear scats during monsoon 30.70% and 13.71% during the

summer. *Ficus benghalensis, Ficus virens* and *Ficus racemosa* are three species distributed in the sanctuary. *Ficus* group is an important fruit plant for all frugivorous species of any forest and are mainly distributed in the central to northern part of the sanctuary, locally known as Vad, Pepar and Gular respectively. The plant occurs in high density in the grid G-5 and lowest densities in grid F-1, H-3 and I-3. This species is present in sloth bear diet and found whole year. These species has detected 26.32% during monsoon, 10.29% summer and 5.52% during winter. The highest density of *Ficus benghalensis* is 25.48 per ha. Whereas, the minimum density is 3.18 per ha for both the *Ficus* species. *Madhuca indica* is distributed in the east-northern part of the sanctuary and locally known as Mahudo (Mahua), this is known as one of liquor plants in India. The plant occurs in the grid I-2 with highest densities and H-2 with lowest densities. This species is reported during the summer when flower blooms 2.29%, as the maximum flower was taken as food, which shows the low frequency because of flower digest, and remaining, which can be detected form scats are very less. The highest density of *Madhuca indica* is 28.66 per ha and minimum density is 6.37 per ha in the study area. Another important species for sloth bear diet, *Phoenix sylvestris* is distributed at the central part of the sanctuary this species locally known as Khajuri. The fruit of *Phoenix* species is well known for their nutrient value. The plant occurs in the grid G-4 and G-5. This species is present in summer diet 28.00% and 9.65% in monsoon. The *Syzygium cumini* and *Syzygium heyneanum* are two species distributed in the sanctuary, *S. cumini* is distributed in the northern

part of the sanctuary this species occur in high density in grid H-4 with 47.77 per ha whereas, the lowest density is 3.18 per ha distributed in I-2 and H-3 grids. Beside this *S. heyneanum* is distributed in southern part in the single grid F-7 with the 12.74 density per ha. *Syzygium* species is present 33.33 % in the scats of sloth bear in monsoon; fruit of *S. cumini* is preferred fruit of sloth bear. *Ziziphus mauritiana* is dominant among all the *Ziziphus* species, it occurs high density in G-5 with 101.82 per ha and G-2, F-5 and G-6 with low density around 25.48 to 9.55 per ha. *Ziziphus* species are important winter diet of the bear and reported 23.93% and if late fruiting is remaining is some of the plants in the study area was reported in the summer diet 3.43% and late fruiting found in the some plants during end of monsoon seasons supports 3.43%.

As this study area comes under the dry, semi-arid zone, in spite of that, in good numbers fruiting species are available in the forest. Maximum varieties of fruiting species for the sloth bear were observed in mix forest types, they are available throughout the year for sloth bear followed by *Acacia tortilis* scrub forest, and least fruiting species for sloth bear are recorded in *Wrightia* and *Miliusa* mixed forest and *Acacia catechu* and *Acacia tortilis* forest (Table 3). Maximum food plants are available in mixed forest and throughout the year (Table 3). While very less food plants were available in the *Wrightia* and *Butea* forest, *Wrightia* and *Miliusa* mixed forest types and clearly seen that, it hardly supports the bear food for the 3 months in a year namely June, July and August. Table 4 shows the fruiting plant species and there seasons in different forest types of study areas.

Table 2. List of tree species with their density and frequency in different forest types of study area (1-*Acacia tortilis* scrub forest, 2-*Diospyros* and *Butea* mixed forest, 3-*Acacia catechu* and *Acacia tortilis* forest, 4-mixed forest, 5-riverine forest, 6-teak and *Miliusa* mixed forest)

Plant species name	1 (n=30)		2 (n=10)		3 (n=10)		4 (n=110)		5 (n=10)		6 (n=10)	
	D ha⁻¹	F (%)	D ha⁻¹	F (%)	D ha⁻¹	F (%)	D ha⁻¹	F (%)	D ha⁻¹	F (%)	D ha⁻¹	F (%)
Aegle marmelos	4.78	15.00	6.37	10.00	35.03	10.00	- -	- -	- -	- -	12.74	30.00
Alangium salvifolium	17.52	25.00	- -	- -	- -	- -	10.42	10.91	- -	- -	25.47	20.00
Anonna squamossa	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Cassia fistula	1.59	5.00	95.39	100.00	- -	- -	6.37	10.91	- -	- -	- -	- -
Cordia dicotoma	- -	- -	3.18	10.00	- -	- -	0.29	0.91	- -	- -	- -	- -
Diospyros melanoxylon	4.78	10.00	- -	- -	- -	- -	33.58	51.82	25.44	50.00	47.69	70.00
Emblica officinalis	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	3.18	10.00
Feronia limonia	6.37	10.00	6.35	10.00	- -	- -	2.32	4.55	- -	- -	- -	- -
Ficus benghalensis	- -	- -	- -	- -	- -	- -	2.90	4.55	- -	- -	- -	- -
Madhuca indica	- -	- -	9.52	20.00	- -	- -	5.21	10.00	28.58	30.00	15.88	40.00
Manilkara hexandra	- -	- -	6.35	10.00	- -	- -	- -	- -	- -	- -	- -	- -
Miliusa tomentosa	- -	- -	- -	- -	- -	- -	19.69	25.45	12.69	30.00	133.29	90.00
Phoenix sylvestris	- -	- -	- -	- -	- -	- -	0.58	0.91	- -	- -	- -	- -
Pongamia pinnata	17.52	15.00	- -	- -	- -	- -	5.79	7.27	12.69	20.00	- -	- -
Syzygium cuminii	- -	- -	6.34	10.00	- -	- -	0.87	0.91	3.17	10.00	- -	- -
Syzygium heyneanum	6.37	5.00	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Terminalia belerica	- -	- -	- -	- -	- -	- -	1.45	2.73	6.34	20.00	25.35	40.00
Ziziphus mauritiana	78.03	65.00	- -	- -	- -	- -	4.34	6.36	- -	- -	- -	- -
Ziziphus xylopyrus	- -	- -	- -	- -	9.50	10.00	1.74	2.73	- -	- -	- -	- -

Table 3. Sloth bear food plant's availability in the forests of Danta and BAWLS (Months from March to February)

Fruiting time in different forest types	No. of fruiting species	Months											
		M	A	M	J	J	A	S	O	N	D	J	F
Acacia tortilis Scrub Forest	8	2	3	5	5	4	2	1	2	2	2	2	2
Diospyros and *Butea* Mixed Forest	6	0	1	2	3	3	3	0	0	2	2	1	0
Acacia catechu and *Acacia tortilis* Forest	2	1	1	1	1	1	0	0	1	1	1	1	1
Mixed Forest	13	2	4	8	8	6	5	3	4	4	4	4	3
Riverine Forest	4	0	1	3	3	2	2	0	0	0	0	0	0
Teak and *Miliusa* Mixed Forest	6	1	2	4	4	2	2	0	0	1	1	1	0
Wrightia and *Butea* Forest	3	0	0	1	2	2	2	0	0	0	0	0	0
Wrightia and *Diospyros* Mixed Forest	4	0	0	2	4	3	3	1	1	0	0	0	0
Wrightia and *Miliusa* Mixed forest	2	0	0	1	2	2	2	0	0	0	0	0	0

Table 4. List of food plants available in different forest types of study area (1-*Acacia tortilis* scrub forest, 2-*Diospyros* and *Butea* mixed forest, 3-*Acacia catechu* and *Acacia tortilis* forest, 4-Mixed Forest, 5-Riverine forest, 6-teak and *Miliusa* mixed forest, 7-*Wrightia* and *Butea* forest, 8-*Wrightia* and *Diospyros* mixed forest, 9-*Wrightia* and *Miliusa* mixed forest)

Species Name	Forest types	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Aegle marmelos	1,3,6	+	+	+	+	+							
Alangium salvifolium	1,4,6,8			+	+								
Annona squamosa	2									+	+		
Cassia fistula	1,4,7	+	+	+	+	+	+	+	+	+	+	+	+
Cordia dicotoma	4			+	+								
Diospyros melanoxylon	1,2,4,5,6,7,8,9			+	+	+	+						
Emblica officinalis	2,6									+	+	+	
Feronia limonia	1,4		+	+	+								
Ficus benghalensis	4	+	+	+	+	+	+	+	+	+	+	+	+
Madhuca indica	2,4,5,6		+	+									
Miliusa tomentosa	2,4,5,6,7,8,9				+	+	+						
Phoenix sylvestris	2,4,8				+	+	+	+	+				
Syzygium cumini	1,4,5			+	+	+							
Syzygium heyneanum	1				+	+							
Ziziphus mauritiana	1,3,4								+	+	+	+	
Ziziphus xylopyrus	4									+	+	+	+

26 species of fruiting plants available in the study area and these fruits are preferred by the sloth bear in BAWLS and Danta RF. Season wise representation of fruiting plants is provided in Table 5.

Discussion

Sign and sightings may be used to define bear distribution (essentially a presence-absence), and changes in distribution may signify changes in abundance (Laurie and Sedensticker, 1977; Rossell and Litvaitis, 1991). Despite myrmecophagous habits, sloth bears are omnivorous and consume large amounts of vegetable matter, particularly fruits (Laurie and Seidensticker, 1977; Gopal, 1991; Gokula, 1991, Litvaitis and Kane, 1994; Gokula *et al.*, 1995). Studies of movement patterns of sloth bears showed that home-range size mainly depended on food supply (Joshi *et al.*, 1995, Desai *et al.*, 1997).

Akhatar *et al.* (2004) found total 30 different food items were in scats (n=1086). Which shows the fruits of gular (*Ficus racemosa*), pakri (*F. virens*), bargad (*F. benghalensis*), peepal (*F. religiosa*), ber (*Ziziphus mauritiana*), bel (*Aegle marmelos*), jamun (*Syzygium cumini*) and mahua (*Madhuca*

indica) in addition to termites (*Odontotermes obesus*) and ants were major food items for sloth bears in MP. While in the present study, we analysed total 566 scats contains 36 food variants including 26 species of plants, 3 groups of insects, different unknown animal matters (bone, feather, etc.). Overall annual frequency occurrence of 26 plant and animal food items, khajur (*P. sylvestris*) and jamun (*S. cumini*) was occurred highest in plant matter in the scats of the sloth bear. Other fruits were also found seasonally like timru (*Diospyros melanoxylon*), bor (*Ziziphus* spp.), garmalo (*Cassia fistula*), gunndaa (*Cordia dichotoma*), Mahua (*Madhuca indica*) and mango (*Mangifera indica*).

According to Johnsingh (1981), the diet of sloth bear in Bandipur National Park, South India, is constituted of insects (53%), fruits (37%) and others (10%) items. In Mundanthurai Wildlife Sanctuary, Gokula *et al.* (1995) has found the composition of bear diet constituted of insects (75%), fruits (25%) and other (1%). An examination of 567 fresh scats at Mudumalai wildlife sanctuary, India, Bhaskaran *et al.* (1997) have found fruits as a major constituent in Sloth bear food. In another study at Mudumalai Wildlife Sanctuary, analysis of 478 scats revealed that the animal matter dominated (52%) over the

Table 5. Fruits availability in different seasons in a year for sloth bear

Fruiting Plant Species	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Aegle marmelos	■	■	■	■								■
Alangium salvifolium			■	■								
Butea monosperma				■	■							
Carrisa congesta			■	■								
Cassia fistula	■	■	■	■	■	■	■	■	■	■	■	■
Catenarigum spinosum							■	■	■	■		
Cordia dichotoma				■	■	■						
Diospyros melanoxylon			■	■	■	■						
Drypetes roxburghii								■	■	■	■	■
Ficus benghalensis	■	■	■	■	■	■	■	■	■	■	■	■
Ficus racemosa		■	■	■	■							
Ficus virens				■	■	■		■	■	■	■	
Grewia flavescens												
Grewia hirsuta		■	■	■				■	■	■	■	■
Grewia tiliafolia			■	■	■			■	■	■		
Madhuca indica		■	■	■								
Mangifera indica		■	■	■	■	■						■
Miliusa tomentosa				■	■	■						
Morinda pubescens								■	■	■		
Phoenix sylvestris				■	■	■	■					
Syzygium cumini			■	■								
Syzygium heyneanum				■	■	■						
Ziziphus mauritiana								■	■	■	■	■
Ziziphus nummularia		■	■	■								
Ziziphus oenoplia									■	■	■	
Ziziphus xylopyrus									■	■	■	■
	Summer (Dray)				Monsoon (Wet)				Winter (Cold)			

plant matter (48%) (Desai *et al*., 1997). In Central India, (Kanha National Park), the diet composition of sloth bear composed of insects (39%) and fruits (61%), (Schaller, 1967). Whereas study by Yoganand *et al*. (2005) at Panna National Park fruits contributed 56%, ants 29% and termites 10% in the diet of sloth bear. Among fruits, *Diospyros melanoxylon* was the highest contributor, followed by *Z. Mauritiana*, and among insects, *Cmponotus* spp. of ants made the greatest contribution to the diet, followed by *Dorylus labiatus* ant. Termites contributed a smaller, but a consistent portion (about 10% to 25%) during most months. Fruits and ants complemented each other and constituted 70% to 95% of the diet (Yoganand *et al*., 2005). Mewada and Dharaiya (2010) reported the dietary composition of sloth bear from Vijayanage forested area of Sabarkantha district of Gujarat. They had observed that in summer, *Ficus* spp. (35%), which is very common in that area and during monsoon and summer season diets (60 and 34% respectively). In winter, *Cassia fistula* was the fruit most frequently taken (84%), along with insects (35%). In a study in the Royal Chitwan National Park, it has been observed that bear fed on 17 different fruits (47%) excluding flower, grass, honey and 6 different insects (52%) (Laurie and Seidensticker, 1977). In a detailed study at Royal Chitwan National Park, Nepal, an analysis of 627 scats showed that diet composition of bears constituted insects (83%), fruits (14%) and others (3%) (Joshi *et al*., 1997). All these research shows the importance of the fruit

in the diet of sloth bear throughout the India. Based on such food habits the preferred fruiting trees in the forest definitely influence the habitat use in the seasonal selection bases. *Ficus* sps and *Cassia fistula* are two important species present in this forest type which are available throughout the year for sloth bear. Maximum movement of sloth bear was observed in *Acacia tortilis* scrub and mixed forest types in the study area. This supports the best food available and 15 species are available for sloth bear. Apart from this *Wrightia* and *Millusa* mixed and *Diospyros* and *Butea* mixed forest types are also good habitats and have good number of fruiting plants for sloth bear.

Management implication

This area is supporting good diversity and inhabited by the tribal communities, which are extensively depending on the forest product use in their day-to-day life. All most all tribal families of this area is involved in the collection of the NTFP (Non Timber Forest Product) or/and Miner Forest Product (MFP). The food is one of the common resources between Sloth bear, other wild animals, human and their livestocks, who, foraged on the same resources. This includes *Ziziphus* Spp., *Diosyros melanoxylon*, *Phoenix sylvestris*, *Syzygium* Spp., *Madhuca indica* and *Ficus* Spp.

The mixed forest supports more diverse fruiting tree, which make food (fruits) available to Sloth bear throughout the year. Here we would like to suggest the forest plantation and management authorities to study the area and plant

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accordingly a mixed fruiting species inside the forest. This may accomplish the bear requirement and advised the tribal to access these fruiting patches during the daytime. Leave the crepuscular and night hours to bear and diurnal hours for us. This may help in reducing the encounter with the bear. Adequate amount of food availability to bear may decrease the sloth bears come out of the forested area.

Educate tribal and forest dweller communities to enhance both their capacity to protect themselves from animal intrusions and their understanding of the importance of sloth bears as seed dispersal, to the forest ecosystem could have significant benefits for both people and bear.

Acknowledgements

Conflicts of interest

The authors declare that there are no conflicts of interest related to this article.

References

Akhatar N, Bargali HS, Chauhan NPS (2004). Sloth bear habitat use in disturbed and unprotected areas of Madhya Pradesh, India. Ursus 15(2):203-211.

Champion HB, Seth SK (1968). A revised survey of the forest types of India. Government of India, Publication, New Delhi.

Chauhan NPS, Bargali HS, Akhtar N (1999). Human- sloth bear conflict in the state of Madhya Pradesh, India. Presented in the 12th international Conference on Bear Research and Management, Romania. Unpublished MS.

Desai, AA, Baskaran N, Venkatesh S (1997). Behavioural ecology of the sloth bear in Mudumalai Wildlife Sanctuary and National Park, Tamil Nadu. Report- A collaborative Project between Bombay Natural History Society and Tamil Nadu Forest Department.

Dharaiya N, Ratnayeke S (2009). Escalating human-sloth bear conflicts in North Gujarat: a tough time to encourage support for bear conservation. International Bear News 18 (3):12-14.

Dharaiya N (2008). Study on the status, distribution and occurrence of certain rare and small mammals in North Gujarat region. Final Report Submitted to Gujarat Forest Research Institute pp 80.

Dharaiya N (2009). Evaluating habitat and human-bear conflicts in North Gujarat, India, to seek solution for human-bear coexistence. Final report submitted to The Ruffords Small Grants Foundation pp 44. (www.ruffordsmallgrants.org)

Garshelis DL, Joshi AR, Smith JLD (1999a). Estimating density and relative abundance of sloth bears. Ursus 11:87-98.

Garshelis DL, Joshi AR, Smith JLD, Rice CG (1999b). Sloth bear conservation action plan. In: Bear status survey and conservation action plan (eds. Servheen C, B Peython): IUCN / SSC bear and polar bear specialist groups. IUCN, Gland, Switzerland pp 309.

Gokula V (1991). Some aspects on the feeding habits of the sloth bear (*Melursus ursinus*) at Mundanthurai Wildlife Sanctuary, Tamil Nadu (South India). M.Sc. Thesis, A.V.C. College, Mannambandal, Tamil Nadu.

Gokula V, Sivaganesan N, Varadarajan M (1995). Food of the sloth bear (*Melursus ursinus*) in Mundanthurai Plateau, Tamil Nadu. Journal of Bombay Natural History Society 92(408):10.

Gopal R (1991). Ethological observations on the sloth bear (*Melursus ursinus*). Indian Forester 117(10):915-920.

Johnsingh AJT (1981). Ecology and behaviour of the dhole or Indian wild dog - *Cuon alpinus*. Pallas (1811):1-57.

Joshi AR, Garshelis DL, Smith JLD (1995). Home ranges of sloth bears in Nepal: implications for conservation. The Journal of Wildlife Management 59:204-214.

Joshi AR, Garshelis DL, Smith JLD (1997). Seasonal and habitat-related diets of sloth bears in Nepal. Journal of Mammalogy 78(2):584-597.

Laurie A, Sedensticker J (1977). Behavioural ecology of the sloth Bears (*Melursus ursinus*). Journal of Zoology 182(2):187-204.

Litvaitis JA, Kane DM (1994). Relationship of hunting technique and hunter selectivity to composition of black bear harvest. Wildlife Society Bulletin 22(4):604-606.

Mewada T, Dharaiya N (2010). Seasonal dietary composition of sloth bear (*Melursus ursinus*) in the reserve forest of Vijaynagar, North Gujarat, India. Tiger Paper 37(2): 8-13.

Mewada TP (2015). Index of relative importance of the dietary proportions of sloth bear (*Melursus ursinus*) in semi-arid region. Notulae Scientia Biologicae 7(3):281-288.

Murthy RS, Sankar K (1995). Assessment of bear-man conflict in North Bilaspur Forest Division, Bilaspur, M. P. Wildlife Institute of India, Dehradun.

Pandey CN (2004). Gujarat's wild destinations. Gujarat Ecological Education and Research Foundation, Gandhinagar, India pp 52-56.

Ratnayeke S, van Manen FT, Padmalal UKGK (2007). Home ranges and habitat use of sloth bears *Melursus ursinus inornatus* in Wasgomuwa National Park, Sri Lanka. Wildlife Biology 13(3):272-284.

Rossell CR, Litvaitis JA (1991). A comparison of methods to estimate the distribution of low-density black bear populations. Transactions of the Northeast Section of the Wildlife Society 48:15-20.

Singh R, Chand K, Patel GA (2002). Management plan for Balaram Ambaji Wildlife Sanctuary. Research and Working circle, Ghandhinagar.

Yoganand K, Rice CG, Johnsingh AJT (2005). Evaluating Panna National Park with special reference to ecology of sloth bear (*Melursus ursinus*). Final Project Report. Wildlife Institute of India, Dehradun, India.